

Noninvasive reactivation of motor descending control after paralysis

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Abstract

© Mary Ann Liebert, Inc. 2015. The present prognosis for the recovery of voluntary control of movement in patients diagnosed as motor complete is generally poor. Herein we introduce a novel and noninvasive stimulation strategy of painless transcutaneous electrical enabling motor control and a pharmacological enabling motor control strategy to neuromodulate the physiological state of the spinal cord. This neuromodulation enabled the spinal locomotor networks of individuals with motor complete paralysis for 2-6 years American Spinal Cord Injury Association Impairment Scale (AIS) to be re-engaged and trained. We showed that locomotor-like stepping could be induced without voluntary effort within a single test session using electrical stimulation and training. We also observed significant facilitation of voluntary influence on the stepping movements in the presence of stimulation over a 4-week period in each subject. Using these strategies we transformed brain-spinal neuronal networks from a dormant to a functional state sufficiently to enable recovery of voluntary movement in five out of five subjects. Pharmacological intervention combined with stimulation and training resulted in further improvement in voluntary motor control of stepping-like movements in all subjects. We also observed on-command selective activation of the gastrocnemius and soleus muscles when attempting to plantarflex. At the end of 18 weeks of weekly interventions the mean changes in the amplitude of voluntarily controlled movement without stimulation was as high as occurred when combined with electrical stimulation. Additionally, spinally evoked motor potentials were readily modulated in the presence of voluntary effort, providing electrophysiological evidence of the re-establishment of functional connectivity among neural networks between the brain and the spinal cord.

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Keywords

motor complete paralysis, neuronal network, transcutaneous spinal cord stimulation, voluntary movements